CALL FORWARDING SYSTEMS, METHODS AND NETWORK DEVICES

Related Application

This Application claims the benefit of U.S. Provisional Application 60/441,121 filed January 21, 2003 5 which is hereby incorporated herein by reference.

Field of the Invention

This invention relates generally to call forwarding systems, methods and network devices in for example distributed peer-to-peer communications networks.

10 Background of the Invention

Some modern communications solutions are based on VoIP (Voice-over IP (Internet Protocol)) technology, which is the transmission of calls over a data network based on the IP. The communication is in the form of packet data and 15 thus there is no fixed connection as there would be in the case of switched networks. The communication can be text, voice, graphics or video. In order to simplify IP communication problems, standards have been developed and adopted in the industry. Examples of such standards are 20 H.323 (Packet based communication systems) and SIP (Session Initiation Protocol). These standards are followed when designing new hardware and software. The SIP standard covers the technical requirements to set-up, modify and tear down multimedia sessions over the Internet. A multimedia 25 communication session between two endpoints will be referred to as a call.

Communication solutions, whether they be switch based or packet based, are defined and designed for a specific number of users and call processing capacity, 30 generally defined by the number of ports (telephone

terminations), and the amount of processing available on a central processing equipment that provides routing and call processing functionality. Hence, equipment vendors generally develop and market versions of the same product

5 for different customer size and needs. However, a customer needs to upgrade to larger central processing equipment once the number of ports required and/or call-processing requirements exceed the capacity of the central processing equipment.

10   Current multimedia communication systems use a central processing equipment and simple user terminal sets. These simple user terminal sets are referred to as "stimulus terminals" as they simply send user stimuli such as key presses to the central processing equipment. In large

15 systems, the central processing equipment is generally a very powerful computer controlling a number of functions on circuit boards called line cards, which connect telephone sets to the computer. The central processing equipment receives hook-switch information and key presses known in

20 the art as DTMF (Dual Tone Multi-Fequency) tones from the telephone sets, and provides feedback to the telephone sets for example by sending a dial-tone or a ringing tone to the telephone sets. By interpreting the key presses, the central processing equipment controls the interconnection of

25 the telephone sets based on numbers dialed by the telephone sets.

         Call forwarding has been provided as part of the central call processing equipment. A trusted entity instructs the central call processing equipment to forward

30 any received calls for a specific telephone set to another telephone set or voice mail under specific conditions. The specific conditions include forwarding to another telephone set a call which is not answered after a specified number of

rings or a call which is destined for a telephone set that is in use (busy with another call). Such a call forwarding system is not well suited for scalability and, as discussed above, when the capacity of the central call processing 5 equipment is exceeded an upgrade is required.

Summary of the Invention

In a call forwarding of a call there is an original calling network device, an original recipient of the call, and a forwardee of the call. Systems, network 10 devices, and methods are provided for delivering call forwarding functionality in a manner such that the call processing involved is performed locally on the network devices themselves without the requirement for central processing equipment. Each network device is capable to 15 function in the capacity of any one or more of the above three roles, namely originator, original recipient, and forwardee by providing local call forwarding functionality. As the requirement for central processing equipment is removed, network devices can be added to a system without 20 incurring high costs of replacing central processing equipment when a system becomes large. Furthermore, a network device may provide a call forwarding destination on behalf of another network device when the other network device cannot be reached. These features enhance system 25 availability and reliability over systems that make use of central call processing for call forwarding.

In accordance with a broad aspect, the invention provides a network device adapted to receive an incoming call. The network device has a call forwarding function 30 adapted to: if the incoming call was intended for an other network device, look-up a call forwarding destination on

behalf of the other network device, and respond to the incoming call with the call forwarding destination.

In accordance with another broad aspect, the invention provides a network device adapted to receive an
5 incoming call. The network device has a call forwarding function adapted to: if the incoming call was intended for an other network device, look-up a call forwarding destination on behalf of the other network device, and initiate a connection with a network device having the call
10 forwarding destination.

In accordance with another broad aspect, the invention provides a network device adapted to participate in call forwarding. The network device has a call forwarding function. For a call initiated with a first
15 other network device, if the first other network device cannot be reached the call forwarding function is adapted to: i) look-up a destination address for a second other network device; ii) initiate an other call to the second other network device; and iii) responsive to a receiving a
20 first message from the second other network device containing a call forwarding destination, respond with a second message to a network device having the call forwarding destination for setting up another call, the call forwarding destination being obtained by the second other
25 network device on behalf of the first network device.

In accordance with another broad aspect, the invention provides a network device adapted to participate in forwarding of a call from the network device to a first other network device. The network device has a call
30 forwarding function adapted to: responsive to receiving a first message from a second other network device for replacing the call with another call with the second network

device, establishing a media path with the second other network device.

In accordance with another broad aspect, the invention provides a network device adapted to participate
5   in call forwarding of call from a first other network device to a second other network device. The second other network device initiates another call to the network device. The network device has a call forwarding function adapted to establish a media path with the first other network device.

10   In accordance with another broad aspect, the invention provides a system in a network having a plurality of network devices each capable of accessing the network. Each network device has a call forwarding function adapted to: a) as an original destination network device, upon
15   receipt of a first call: i) look-up a call forwarding destination; and ii) provide destination information associated with the call forwarding destination of a network device from which the first call originates; and b) as an originator network device of a second call responsive to
20   receiving a message containing destination information of an other network device, establish a media path with the other network device.

In accordance with another broad aspect, the invention provides a system in a network having a plurality
25   of network devices each capable of accessing the network. Each network device has a call forwarding function adapted to: a) as an original destination network device, upon receipt of a first call: i) look-up a call forwarding destination; and ii) send a first message to a network
30   device having the call forwarding destination for setting up a call with the network device having the call forwarding destination; and b) as an originator network device of a

second call: responsive to receiving a second message
containing destination information of an other network
device, establishing a media path with the other network
device.

5   In accordance with another broad aspect, the
invention provides in a network device, a method that
involves responsive to receiving an incoming call from a
first other network device: if the incoming call was
intended for an other network device, looking-up a call
10   forwarding destination on behalf of the other network
device, and responding to the incoming call with the call
forwarding destination.

Brief Description of the Drawings

          Preferred embodiments of the invention will now be
15   described with reference to the attached drawings in which:

          Figure 1 is an example implementation of a system
that makes use of network based distributed peer-to-peer
call processing;

          Figure 2 is a partial circuit block diagram of a
20   terminal set of the system of Figure 1;

          Figure 3 is a functional block diagram of software
operating on a terminal set of Figure 1;

          Figure 4 is a functional block diagram of a call
processing module of the software of Figure 3;

25   Figure 5 is a routing table of a terminal set of
Figure 1;

          Figure 6 is a flow chart of a method of initiating
a call from one network device to another network device
which might for example be employed in the system of Figure

Figure 7A is a basic block diagram of a distributed peer-to-peer network;

Figure 7B is another basic block diagram of a distributed peer-to-peer network;

5   Figure 8A is a signal flow diagram of the basic steps which take place in a call forwarding scenario, according to an embodiment of the invention;

Figure 8B is a signal flow diagram of the basic steps which take place in a call forwarding scenario, 10   according to another embodiment of the invention;

Figure 8C is a signal flow diagram of the basic steps which take place in a call forwarding scenario, according to another embodiment of the invention;

Figure 8D is a signal flow diagram of the basic 15   steps which take place in a call forwarding scenario, according to another embodiments of the invention;

Figure 9 is a signal flow diagram of an example implementation of call forwarding in a distributed peer-to-peer network, according to another embodiment of the 20   invention;

Figure 10 is a flow chart of a method of determining whether or not a call requires to be forwarded, according to another embodiment of the invention;

Figure 11 is a signal flow diagram of an example 25   implementation of call forwarding in a distributed peer-to-peer network when a target network device cannot be reached;

Figure 12 is a signal flow diagram of an example implementation of call forwarding in a distributed peer-to-

peer network, according to another embodiment of the invention; and

Figure 13 is a signal flow diagram of an example implementation of call forwarding in a distributed peer-to-
5 peer network when a target network device cannot be reached.

Detailed Description of the Preferred Embodiments

Embodiments of the invention provide a call forwarding system which is implemented locally on network devices. In call forwarding systems, a user enables call
10 forwarding using any suitable method such as pressing a call forwarding key on a network device and entering a call forwarding destination for example. Once call forwarding has been enabled, calls that are then received at the network device which are intended for the network device are
15 forwarded to a network device having the call forwarding destination. In some embodiments of the invention, network devices in a network provide call forwarding functionality locally. In some embodiments of the invention, this call forwarding functionality can be implemented as part of a
20 call processing capability that incorporates other call processing features. An example implementation of an embodiment of the invention will be described with reference to Figures 1 to 6 in the context of call processing on a peer-to-peer distributed network which incorporates call
25 forwarding.

Referring to Figure 1, shown is an example implementation of a system generally indicated by 10 which makes use of network based distributed peer-to-peer call processing. In addition to call forwarding, in the example,
30 call processing functionality such as call transfer, call park and pickup, voice mail, and paging, and other features such as time synchronization, backup features, and peer

discovery, may be provided locally at network devices within a network. Such features and functionality are described in U.S. Provisional Patent Application number 60/441,481 entitled "DISTRIBUTED PEER-TO-PEER CALL TRANSFER SYSTEM,

5   METHOD AND TELEPHONE TERMINALS" and filed January 22, 2003; U.S. Provisional Patent Application number 60/441,121 entitled "DISTRIBUTED PEER-TO-PEER CALL FORWARDING SYSTEM, METHOD AND TELEPHONE TERMINAL" and filed January 21, 2003; U.S. Provisional Patent Application Number 60/434,813

10 entitled "DISTRIBUTED PEER-TO-PEER VOICE MAIL SYSTEM, METHOD AND TELEPHONE TERMINALS" and filed December 20, 2002; U.S. Provisional Patent Application number 60/473,877 entitled "DISTRIBUTED PEER-TO-PEER CALL PARK AND CALL PARK PICKUP SYSTEM, METHOD AND TELEPHONE TERMINALS" filed May 29, 2003;

15 U.S. Provisional Patent Application entitled "PEER-TO-PEER DISCOVERY SYSTEM, METHOD AND NETWORK DEVICES" <attorney docket no. 50447-5> filed November 12, 2003; U.S. Provisional Patent Application entitled "PEER BACK-UP IN A DISTRIBUTED PEER-TO-PEER NETWORK: SYSTEM, METHOD AND NETWORK

20 DEVICES" <attorney docket no. 50447-6> filed November 21, 2003; U.S. Provisional Patent Application entitled "TIME SYNCHRONIZATION OF NETWORK DEVICES IN A NETWORK: SYSTEM, METHOD AND NETWORK DEVICE" <attorney docket no. 50447-7> filed November 19, 2003; U.S. Provisional Patent Application

25 entitled "SYSTEM, METHOD AND NETWORK DEVICES FOR PAGING IN A NETWORK" <attorney docket no. 50447-8> filed November 24, 2003; U.S. Patent Application entitled "VOICE MAIL SYSTEM, METHOD AND NETWORK DEVICES" <attorney docket no. 50447-9> filed December 22, 2003, all of which are incorporated

30 herein by reference. It is to be clearly understood that embodiments of the invention are also provided which only provide call forwarding functionality.

The system 10 has a TTI (Thin Trunk Interface) 40 and five terminal sets 101, 102, 103, 104, 105 on a network 30. The network 30 may be for example a LAN (Local Area Network). In the example of Figure 1 there are five

5   terminal sets 101, 102, 103, 104, 105; however, more generally there are a total of N terminal sets where N ≥ 2. Furthermore, in some implementations N can be a large number, for example in the thousands. The TTI 40 is, for example, a basic Analog or digital T1/E1 interface or any

10   other suitable PSTN interface and provides a local central office or PSTN (Public Switched Telephone Network) interworking interface. The TTI 40 is coupled to a number of telephone "lines" 1, 2, 3, 4. Lines 1, 2, 3, 4 are wire pairs representative of facilities provided by a local

15   central office or PSTN (not shown). In some implementations, there are many lines requiring multiple thin trunk interfaces. For example, in one implementation, 8 lines are required for connection to the PSTN and a second thin trunk interface is added to the system 10. It is to be

20   understood that the system 10 of Figure 1 is only a specific example of the incorporated subject matter. For example, in some implementations the network 30 form part of a larger network that is a collection of smaller networks interconnected by way of VPN (Virtual Private Network)

25   connections for example.

In another example implementation there are two or more networks each having a TTI and at least one network device capable of providing call forwarding functionality locally. An external call received from a network device on

30   another network is routed through a respective TTI on the network on which the network device intended to receive the call resides. The network device receiving the external call provides local call forwarding functionality for the

external call if required. In the event that the network

device intended to receive the call is unavailable the TTI

through which the call is routed re-routes the call to

another network device designated as a backup network device

5   for the network device originally intended to receive the

call.

Unlike conventional systems, the system 10 of

Figure 1 features distributed call processing, and a number

of capabilities including distributed call forwarding.

10   Referring to Figure 2, shown is a partial circuit

block diagram of terminal set 101 of Figure 1. Terminal

sets 102, 103, 104, 105 are similar to terminal set 101 and

have a circuit that can be equally represented by the

partial circuit block diagram of Figure 2. A CPU (Central

15   Processor Unit) 530, a MMU (Memory Management Unit) 545 and

a RAM (Random Access Memory) 535 form a processing device

536. The processing device 536 is connected to a Digital

Signal Processing (DSP) 520 for encoding and decoding audio

signals. The DSP 520 is connected to an audio interface

20   510. The processing device 536 is also connected to a 3-

port switch 525 to allow connection to the LAN 30 and/or a

PC (Personal Computer). The processing device 536 is also

connected to a non-volatile flash memory 540, an IR

(Infra-Red) interface 550, a Keypad and button interface

25   555, an LCD (Liquid Crystal Display) controller 560, and a

PCMCIA (Personal Computer Memory Card International

Association) Interface 565 to allow for standardized

expansion of the terminal set 101. While a specific

architecture is shown in Figure 2, it is to be understood

30   that the invention is not limited to the architecture shown

in Figure 2. More generally, in some implementations, a

portion of or all of the functionality provided by the

partial circuit block diagram of Figure 2 is implemented on

any network device, such as a terminal set, the TTI 40, and a PC (Personal Computer) for example. Preferably, the network device is a packet based telephone such as an VoIP (Voice over Internet Protocol) telephone terminal set.

5 Other examples are video phone, a PDA (Personal Digital Assistant), a soft phone, a wireless device, or a wireless telephone that can be suitably programmed and configured to provide the distributed call forwarding functionality described below. In some cases, the terminal sets are for

10 example IP phones such as that manufactured by Mitel, Nortel, Avaya, Siemens, NEC, Pingtel or 3COM.

Referring to Figure 3, shown is a functional block diagram of software operating on terminal set 101 of Figure 1. The software will be described as operating on terminal

15 set 101; however, it is to be understood that similar software is implemented in terminal sets 102, 103, 104, 105. Furthermore, in some cases, at least some of the features of the software described below are implemented in any network device such as the TTI 40 for example. The software is

20 stored in RAM 535 of Figure 2 and runs on the CPU 530. More generally, the software can be implemented as any suitable combination of instructions stored in memory for execution by general or special purpose processors, firmware, ASICs (Application Specific Integrated Circuits), FPGAs (Field-

25 Programmable Gate Arrays), and general or special purpose logic. A system dispatcher 120 provides communication and scheduling between various functional elements which include a call processing module 70, a voice mail module 80, a dialing rules module 90, a peer discovery module 110, a

30 display handler 130, an audio handler 140, an input handler 150, and a peer back-up module 160. The call processing module 70 also interfaces with a protocol stack 60.

Figure 3 shows a detailed example of functions
that may be included in a network device; however, it is to
be understood that a network device need not have all of the
functions shown in Figure 3 and that in some implementations
5 a network device will have only some of the functionality
shown in Figure 3. The display handler 130 formats
information and displays the information to a user. The
input handler 150 monitors inputs from for example key
presses, hook switch, volume keys, and hands free and mute
10 buttons and informs the system dispatcher 120. The system
dispatcher 120 then distributes messages to other modules
for further appropriate action to be taken. The audio
handler 140 plays audio tones such as ringing, busy, and
call waiting tones and/or connects to a handset speaker or
15 speaker phone through a media call upon receipt of an audio
message from the system dispatcher 120.

When terminal set 101 is initially connected to
the network 30 it performs a peer discovery by executing the
peer discovery module 110. At this point terminal set 101
20 undergoes a discovery of peer network devices such as
terminal sets 102, 103, 104, 105 and TTI 40 by way of
messages between terminal set 101 and terminal sets 102,
103, 104, 105 and TTI 40. Once the peer terminal sets are
discovered, information is exchanged between the terminal
25 set 101 and the peer network devices. At least part of the
information exchanged in the messages is included in a
routing table illustrated by way of example as shown in
Figure 5. The routing table is generally indicated by 200
and contains routing information for each of terminal sets
30 101, 102, 103, 104, 105 and TTI 40. A column 210 contains a
DN (Directory Numbers) for each terminal 101, 102, 103, 104,
105. For example, in one case terminal sets 101, 102, 103,
104 have DNs 201, 202, 203, 204, 205 respectively. The DN

uniquely identifies terminal sets 101, 102, 103, 104, 105 within the network 30. In the example implementation the TTI 40 is not a user dialable device. TTI 40 is given a different identifier T01 so that it can nonetheless be
5 identified by other network devices. A column 220 has as entries a MAC (Media Access Control) address for each terminal set 101, 102, 103, 104, 105 and TTI 40. A column 230 has as entries an IP (Internet Protocol) address assigned to each terminal set 101, 102, 103, 104, 105 and
10 TTI 40. A column 240 indicates a current device status of each terminal set 101, 102, 103, 104, 105 and TTI 40. For example, in one implementation a "1" indicates that a network device is up and running whereas a "0" indicates that the network device is un-available due to, for example,
15 a failure.

In some implementations, a network device has one or more network devices designated to serve as backup network devices in the event the network device is unavailable to process a call. In particular, if a network
20 device is unavailable to process a call, the call is re-directed to one of its designated backup network devices and the designated backup network device receiving the re-directed call provides call functionality for the network device that is unavailable. In the example of Figures 1 to
25 3, and 5 for each terminal set 101, 102, 103, 104, 105 there are two network devices designated as backup network devices which are identified in columns 260, 270 of the routing table 200. For example, network devices having DNs 202, 205 in columns 260, 270, respectively, are designated as backup
30 network devices for terminal set 101 which has DN 201. In the example implementation, the TTI 40 (T01) is not backed up; however, as further discussed below in some implementations the TTI 40 is backed up by one or more

network devices. As shown in the routing table 200, there are preferably two backup network devices designated for each network device; however, more generally, there is one or more backup network devices designated for each network

5 device. In our example implementation, in columns 260, 270 the backup network devices are identified by their DNs for clarity. Some implementations make use of DNs to identify backup network devices as illustrated. In other embodiments of the invention, MAC addresses are maintained in columns

10 260, 270 to identify the backup network devices. Furthermore, any unique identifier for the network devices may be used. The routing table 200 is shown as an illustrative example of the type of routing information that might be maintained; however, the invention is not limited

15 to the illustrative example of Figure 5 and in other implementations fewer or additional routing information is maintained in the routing table 200. More generally, the routing table 200 may contain any information on network devices, which is maintained for providing local

20 functionality such as voice mail, call transfer, call forward, paging, and backup functionality. Other information that may also be maintained in table 200 might be for example, network device type identifiers, timestamps for synchronization purposes, network class identifiers for

25 identifying a network class on which a network device is connected, and activity indicators identifying whether network devices are active. For purposes of providing backup functionality entries in columns 260, 270 are maintained. On a more simplified level, each network device

30 maintains an identification of its designated backup network devices and an address for each designated backup network device. In particular, when a new network device is added to the network 30, the network device makes use of its peer discovery module 110 to obtain routing information

pertaining to other network devices in the network 30 and makes use of the peer backup module 160 to designate two other network devices as backup network devices. In some implementations, maintaining column 260, 270 involves

5 periodically redistributing backup designations to prevent, for example, a network device form continuously providing backup functionality for another network device that is prone to failure. Periodic redistribution of backup designations provides a fair distribution of workload in

10 providing voice mail backup functionality among the network devices.

Referring back to Figure 3, the dialing rules module 90 contains and/or applies a set of dialing rules for the call-processing module 70, which control how calls are

15 directed. As an example of a dialing rule, a dialing rule might allow a terminal set to apply one or a set of filters to numbers dialed and if a match is found then the call is routed via a specific route to its destination.

The call-processing module 70 interacts with the

20 protocol stack 60 to set up and tear down calls, and to set up media calls. When a call is received and a user is unable to answer the call because he or she is taking another call or because he or she is away from the terminal set, then the call may be optionally handled by the voice

25 mail module 80.

The call processing modules of a number of network devices collectively serve to deliver PBX-like (Private Branch Exchange-like) call processing capabilities in a distributed fashion without the need for a PBX (Private

30 Branch Exchange). For example, the call processing module 70 of terminal set 101 handles calls not only intended for terminal set 101 but also handles calls for other network

devices for which it has been designated as a backup
terminal set. This allows the voice mail module 80 to
handle calls for the other network devices for which
terminal set 101 has been designated as a backup terminal
5   set. With reference to columns 210, 260 of the routing
table 200, the network devices having DNs 202 and 205 both
have designated as a first backup network device the network
device having DN 201. As such, the network device having DN
201 provides voice mail functionality for calls not only
10   intended for itself but also for calls intended for the
network devices having DNs 202, 205. In particular, when
the network device having DN 202 is unavailable, the network
device having DN 201 will serve as a backup network device
to provide call processing and/or voice mail functionality
15   for calls intended for the network device having DN 202.
Similarly, when network device having DN 205 is unavailable,
the network device having DN 201 will serve as a backup
network device to provide call processing and/or voice mail
functionality for calls intended for the network device
20   having DN 205.

An example implementation of the call processing
module 70 together with the protocol stack 60 is shown in
Figure 4. In Figure 4, the call processing module 70 has
four call threads 72, 73, 74, 75 and a CP (Call Processor)
25   dispatcher 71. The protocol stack 60 has a Tx (Transmit)
stack 55 and an Rx (Receive) stack 65. Incoming calls are
queued in the Rx stack 65 and outgoing calls are queued in
the Tx stack 55. A channel 50 provides a connection to the
network 30 for the incoming calls and a channel 52 provides
30   a connection to the network 30 for the outgoing calls. The
incoming and outgoing calls may be for example in the form
of messages that are for example requests, responses to
request, messages containing information such as routing
information for other network devices, messages containing

information such as routing information from other network devices, and messages containing media information. The requests may be for example, requests for establishing connections, requests for terminating connections, or media

5 data such as voice.

Each of the call threads 72, 73, 74, 75 is capable of handling a respective call. For example, a media call received by the terminal set 101 may be processed by the call thread 72, while a voice mail message may be recorded

10 simultaneously on call thread 73. In addition, the call thread 74 might at the same time be involved in recording a voice mail message intended for another network device for which terminal set 101 is designated as a backup. The CP dispatcher 71 manages the call threads 72, 73, 74, 75 and

15 performs scheduling of incoming and outgoing calls. In addition, the four call threads 72, 73, 74, 75 provide a mechanism for simultaneously handling 3-way conferencing plus voice mail. The invention is not limited to four call threads and in other implementations, there are two or more

20 call threads. In some implementations in which there are two call threads, the two call threads might be used to simultaneously handle an incoming call and another call intended for voice mail, paging, or call forwarding for example.

25 When an incoming message for a call arrives at the protocol stack 60 through channel 50, the incoming message is queued in the Rx stack 65 and then sent to the CP Dispatcher 71. The CP dispatcher 71 determines the thread 72, 73, 74, 75 to which the call is to be sent and forwards

30 the message to the determined thread. Each call thread 72, 73, 74, 75 is capable of interfacing with the voice mail module 80, the dialing rules module 90, the peer discovery module 110, the display handler 130, the audio handler 140,

the input handler 150, and the peer backup module 160. The call threads 72, 73, 74, 75 are shown interfacing with the voice mail module 80, the dialing rules module 90, and the CP dispatcher 71 only for purposes of clarity. The module

5   or modules that a call thread interfaces with depends on the type of message being received or made. For example, if the message is intended for voice mail, the voice mail module 80 interfaces with the call thread. In response to the received message one of the call threads 72, 73, 74, 75

10 interfacing with one or more of the modules if necessary and generates a response message to the Tx stack 55 of the protocol stack 60 to be packaged and sent to a destination network device. The message contains information provided by one or more of the modules 80, 90, 110, 130, 140, 150,

15 160. The type of message being sent back to the network 30 depends on the state of the call thread. If, for example, the call received corresponds to an INVITE message for initiating a new call under a SIP (Session Initiation Protocol) then the response is an appropriate

20 acknowledgement such as a RINGING message indicating that the terminal set is ringing or an OK message indicating that the call has been answered.

Referring to Figure 6, shown is a flow chart of a method of initiating a call from one network device to

25 another network device which might for example be employed in the system 10 of Figure 1. In particular, a caller at an originator network device wishes to call a person at a destination network device. At step 600, the originator network device attempts to establish a connection for a call

30 with the destination network device. At step 605, if the connection is established the call is processed (step 650). The attempt may be unsuccessful due to for example one or more of a network failure, failure at the destination

network device, the destination network device being
unplugged and lack of resources at the destination network
device to process a call. In some cases, the lack of
resources might be due to for example all call threads at

5 the destination network device being used simultaneously.
At step 605 if the attempt is unsuccessful, then the
originator network device looks up its routing information
to determine which network device is to serve as a first
backup network device for the destination network device and

10 to determine an address for the first backup network device.
The originator network device then initiates a call to the
first backup network device by attempting to establish a
connection using the address of the first backup network
device (step 610). At step 615, if the attempt is

15 successful and a connection is established with the first
backup network device, the call is processed (step 651).
Again, the attempt at the connection with the first backup
network device may be unsuccessful and at step 615, if the
attempt of step 610 fails, then the originator network

20 device looks up its routing information to determine which
network device is to serve as a second backup network device
for the destination network device and to determine an
address for the second backup network device. The
originator network device then initiates a call to the

25 second backup network device by attempting to establish a
connection using the address of the second backup network
device (step 620). At step 625, if the attempt is
successful and a connection is established with the second
backup network device, the call is processed (step 652).

30 The originator network device has a generic call processing
capability that allows the originator network device to take
the call locally and provide voice mail functionality
locally using a generic greeting. In particular, there is a
user option for enabling the generic call processing

capability. At step 625, if the attempt of step 620 is unsuccessful, a determination of whether the generic call processing capability is enabled is determined (step 630). At step 630, if the generic call processing capability is

5   enabled a connection is established locally, a generic voice mail greeting is played and a voice mail message from the caller initiating the call is recorded and later sent to the destination network device when the destination network device becomes available (step 640). At step 630, if the

10 generic voice mail functionality is disabled a busy tone is played to the caller (step 660).

In the example of Figure 6, it is assumed that for steps 600, 610, 620 the destination network device, the first backup network device, and the second backup network

15 device, respectively, are available before a connection is attempted; however, in some implementations at the steps 600, 610, 620 a look-up in column 240 of the routing table 200 is performed to first determine whether a network device for which a connection is to be established is active. An

20 attempt at a connection is then performed only if the network device is active.

Regarding processing at the destination network device, in one implementation at step 650 the call is processed with a ringing signal being generated for

25 answering of the call by a user at the destination network device and only after a pre-determined number of ring is a voice mail message taken. However, at steps 651, 652, 640, the call is directly processed by a call processing thread in cooperation with the voice mail module of the network

30 device answering the call, whether it be a designated backup network device (step 651 or 652) or the originator network device (step 640).

Whether it be the destination network device (step 650), or one of the designated backup network devices (step 651 or 652), or the originator network device (step 640), the network device that accepts the call preferably does so

5 in a manner that is unique to the original destination telephone set. This might for example involve having each network device maintain its own specific voice mail greeting and other greetings specific to the network devices the designated as backup network devices. Furthermore, in some

10 implementations, each network device maintains user options for handling voice mail and call forwarding.

In the method of Figure 6, each network device is assigned two other network devices as backup network devices and as such there are up to two attempts at establishing

15 connections with network devices designated as backup network devices (steps 610, 620). More generally, a network device has M other network devices designated as backup network devices with $M \geq 1$ and successive attempts at establishing connections with the M backup network devices

20 are performed until one of the attempts is successful. Again, in some implementations the status of a network device is first looked-up and an attempt at a connection with the network device is performed only if the status indicates that the network device is active. As such in

25 some cases, there are $0 \leq N \leq M$ attempts at establishing connections with backup network devices. If none of the attempts are successful then the call is handled locally as described with reference to steps 630, 640, 660. Furthermore, in some implementations, there is no generic

30 call processing capability as described with reference to step 640 in which case when the attempt at step 625 is unsuccessful, the caller is provided with a busy tone (step 660).

In the example implementation of Figures 1 to 6, the TTI 40 is not backed up by another network device; however, in some implementation the TTI 40 is backed up by one or more other network devices. In some embodiments of

5   the invention each network device is backed up by one or more network devices. Preferably, for each network device one or more network devices of the same type are designated as backup network devices. For example, in some embodiments of the invention a telephone terminal set has one or more

10 other telephone terminal sets designated as backups and a TTI has one or more other TTIs designated as backups.

The method of Figure 6 will now be described for a specific example in which a user at terminal set 101 of Figure 1 attempts to make a call to terminal set 103. In

15 this specific example terminal sets 101 and 103 correspond to the originator and destination network devices, respectively. In the specific example terminal sets 101, 102, 103, 104, 105 have DNs 201, 202, 203, 204, 205, respectively. As shown in columns 210, 260, 270 of the

20 routing table 200, the network devices having DNs 202, 204 (terminal sets 102 and 104) are designated as backup network devices for the network device having DN 203 (the destination network device corresponding to terminal set 103). At step 600 terminal set 101 attempts to establish a

25 connection for a call with terminal set 103. At step 605, if the connection is established the call is processed by terminal set 103 (step 650). At step 605 if the attempt is unsuccessful, then the terminal set 101 looks up its routing table 200 to determine from column 260 that terminal set 102

30 (DN 202) is to serve as a first backup terminal set for terminal 103 (DN 203) and determines from column 220 or 230 an address for terminal set 102. In some implementations, the call processing module 70 is responsible for retrieving the address of the first backup network device and for

providing instructions for connecting to the first backup
network device. The terminal set 101 then initiates a call
to the terminal set 102 by attempting to establish a
connection using the address of terminal set 102 (step 610).

5   At step 615, if the attempt of step 610 is successful and a
connection is established with terminal set 102, the call is
processed by terminal set 102 (step 651). At step 615, if
the attempt of step 610 fails, then terminal set 101 looks
up its routing table 200 to determine from column 270 that

10   terminal set 104 (DN 204) is to serve as a second backup
terminal set for terminal set 103 (DN 203) and to determine
from column 220 or 230 an address for the terminal set 104.
The terminal set 101 then initiates a call to terminal set
104 by attempting to establish a connection using the

15   address of terminal set 104 (step 620). At step 625, if the
attempt is successful and a connection is established with
terminal set 104, the call is processed by terminal set 104
(step 652). At step 625, if the attempt of step 620 is
unsuccessful, a determination of whether the generic call

20   processing capability is enabled is determined (step 630).
At step 630, if the generic call processing capability is
enabled a connection is established locally, a generic voice
mail greeting is played and a voice mail message from the
caller initiating the call at terminal set 101 is recorded

25   and later sent to terminal set 103 when terminal set 103
becomes available (step 640). At step 630, if the generic
voice mail functionality is disabled a error tone such as a
fast busy is played to the caller at terminal set 101 (step
660).

30   The method of Figure 6 describes how a network
device attempts to establish a call and in some cases the
call is answered by way of voice mail. The manner in which

a network device participates in forwarding of a call using local call forwarding functionality will now be described.

Call Forwarding

Embodiments of the invention provide a call
5   forwarding system, methods, and network devices for forwarding calls between an originator network device and another packet network device to a destination network device without the requirement of a switch or central processing equipment.

10   A first set of embodiments will be described with reference to Figures 8, 9, and 11. In these embodiments, forwarding is achieved by responding to incoming messages requesting call setups with messages which refer the original caller to a forwarding destination address.
15 Further embodiments will be described with reference to Figures 12 and 13. In these embodiments, call forwarding is implemented by a network device on which call forwarding has been enabled by sending a request for a connection directly to a target forwarding address. These embodiments will each
20 be described in detail below.

        Referring to Figure 7A shown is a basic block diagram of a distributed peer-to-peer network. In Figure 7A shown are first, second, third and fourth network devices 1001, 1002, 1003, 1004 on a network 1000. Each network
25 device 1001, 1002, 1003, 1004 has a call processing module 1010 having a CFF (Call Forwarding Function) 1015, and a user interface 1020. The call processing module 1010 of the network devices 1001, 1002, 1003, 1004 is adapted to process calls using the CFF 1015 to provide local call forwarding
30 functionality. In some embodiments of the invention, the call processing functionality of the call processing module described above with reference to Figures 1 to 6 is

implemented in the call processing modules 1010; however, it is to be clearly understood that in other embodiments only some of the call processing features described above are implemented and other call processing feature may also be

5   implemented. The user interface 1020 is adapted to receive a user input enabling or disabling call forwarding to other network devices. In Figure 7A, the CFF 1015 is implemented as part of the call processing module 1010; however, the invention is not limited to the CFF 1015 being implemented

10   as part of the call processing module 1010 and in some embodiments of the invention the CFF 1015 is distinct from the call processing module 1010. In the description that follows, it is assumed that the CFF 1015 is implemented as part of the call processing module 1010. Furthermore, the

15   CFF 1015 is implemented in any suitable way including software, hardware, or firmware for example.

Each network device 1001, 1002, 1003, 1004 may be for example a terminal set, a packet based telephone, a VoIP (Voice over Internet Protocol) telephone, a video phone, a

20   PC (Personal Computer), a PDA (Personal Digital Assistant), a soft phone, a wireless device, or a wireless telephone suitably programmed and configured to provide call forwarding functionality.

For each network device 1001, 1002, 1003, 1004 the

25   call processing module 1010 provides call forwarding functionality as one or more of an original calling network device, an original recipient of a call to be forwarded, and a forwardee of a call using the CFF 1015.

In some cases call forwarding is enabled/disabled

30   through the user interfaces 1020. This can be implemented through keys or buttons which are specifically programmed to implement these functions. Alternatively, soft keys can be

provided which provide these functions. Preferably, the user interface 1020 includes a mechanism for enabling and disabling call forwarding, a mechanism for specifying a target or destination network device (forwardee) to receive

5   calls which are to be forwarded. Furthermore, in preferred embodiments, each network device has a one or more backup network devices defined within a network which provide backup processing as described previously with reference to Figure 1 to 6; however, it to be understood that the

10 invention is not limited to backup processing as described above and in some embodiments of the invention only some of the previously described backup processing features are implemented. Furthermore, other backup processing features may be implemented. Preferably, when the user interface

15 1020 of one of the network devices 1001, 1002, 1003, 1004 receives call forwarding instructions such as a call forwarding address, this information is also passed to the backup network devices so that they can handle the call forwarding functionality in the event the original network

20 device cannot be reached. Once call forwarding is enabled, incoming calls intended for the network device receiving the incoming calls are forwarded to another network device. There are different conditions which can trigger forwarding of a call. For example, a setting might be used to forward

25 all incoming calls. Another setting might be used to forward incoming calls when the network device is busy. Yet another setting might be used to forward incoming calls after N rings. Furthermore, a network device might be configured to forward a call to another network device using

30 a call forwarding destination or forward the call for voice mail processing.

A call forwarding might be implemented on demand for example by providing a user input using the user

interface 1020 with the user input containing a call
forwarding destination. In addition, in some embodiments of
the invention call forwarding data such as call forwarding
destinations are distributed to each network device on a
5   network. Alternatively, the call forwarding data is stored
centrally on a file server for example.

Furthermore, preferably the user interface 1020
includes functionality for selecting between an
unconditional call forwarding option, a call forwarding
10   after N rings, and call forwarding on busy. The
unconditional call forwarding option will forward the call
as soon as it is received whereas the forwarding after N
rings option will first ring the original destination some
predetermined number of rings and then if the call is not
15   answered the call forwarding function kicks in and forwards
the call to an identified forwarding destination.

Referring now to Figure 8A, shown is a signal flow
diagram of the basic steps which take place in a call
forwarding scenario. As an illustrative example of a
20   particular scenario, a call that originates from the first
network device 1001 is directed to the second network device
1002 and then forwarded to the third network device 1003.
However, it is to be understood that there are other
possible scenarios. More generally, a call might originate
25   from any one of network devices 1001, 1002, 1003, 1004; be
received by any first other one of network devices 1001,
1002, 1003, 1004; and forwarded to a second other one of
network devices 1001, 1002, 1003, 1004.

Firstly, a user at the first network device 1001
30   decides to initiate a call to a user at the second network
device 1002 and the first network device 1001 sends a call
setup message 800 to the second network device 1002. The

second network device 1002 processes the call setup message 800 and determines whether or not the call requires to be forwarded, details of which are described herein below with reference to Figure 10. When call forwarding is enabled, a

5 call forwarding destination is looked-up for the second network device 1002 is obtained is packed in a REFER request 810 which is sent back to the first network device 1001. Preferably the call forwarding destination is looked-up locally at the second network device 1002 in for a example a

10 table maintained by the network device 1002. Alternatively, the call forwarding destination is looked-up at a central location. The first network device 1001 receives the REFER request 810 and sends a new call setup message 820 to the third network device 1003 which corresponds to the call

15 forwarding destination provided by second network device 1002 in the REFER request 810.

Referring now to Figure 8B, shown is a signal flow diagram of the basic steps which take place in a call forwarding scenario, in accordance with another embodiment

20 of the invention. The messaging sequence is between the first, second, and third network devices 1001, 1002, 1003. A user at the first network device 1001 decides to initiate a call to a user at the second network device 1002 and the first network device 1001 sends call setup message 800 to

25 the second network device 1002. The second network device 1002 processes the call setup message 800 and determines whether or not the call requires to be forwarded, details of which are described herein below with reference to Figure 10. When call forwarding is enabled, a call forwarding

30 destination of the third network device 1003 is looked-up and a call setup message 830 is sent to the third network device 1003. The third network device 1003 responds with message 840 which is sent to the second network device 1002.

The second network device 1002 then sends a message 850 containing a reference to the third network device 1003 to the first network device 1001. The first network device 1001 then sends the call setup message 820 to the third

5 network device 1003. In some implementations there is no message 840 being sent to the second network device 1002. Furthermore, in some embodiments of the invention the call setup message 830 contains a reference to the first network device 1001. In some of these embodiments the first and

10 third network devices 1001, 1003 establish a media path with each other without the call setup message 820 being sent to the third network device 1003. In some embodiments of the invention, messages 840, 850 and 820 contain a reference to the call between the second and third network devices 1002,

15 1003. In some embodiments of the invention this reference to the call between the second and third network devices 1002, 1003 corresponds to a reference to the call between the first and second network devices 1001, 1002. In some embodiments of the invention, the call setup message 830

20 contains a reference to the first network device 1001 and the third network device 1003 sends message 840 directly to the first network device 1001 instead of the second network device 1002 in which case there is no message 850 being sent.

25   Another embodiment provides a system which consists of a network; a plurality of network devices each capable of accessing the network, each network device being adapted to perform local call forwarding. Each network device is preferably one of the above summarized network

30 devices.

In yet another embodiment, the system 1005 also has a TTI (Thin Trunk Interface) connected to the network with the TTI having at least some call forwarding

functionality. In this embodiment, for call forwarding to and from external network devices outside the network 1000, the TTI is adapted to provide local call forwarding functionality as a forwardee or an originator, respectively,

5   for the external network devices outside the network 1000.

As shown in Figure 7B, there is a TTI 1030 having a call processing module 1040, which is connected to the network 1000. The call processing module 1040 is capable of directing calls between the network devices 1001, 1002,

10   1003, 1004 and external network devices (not shown) outside the network 1000. Furthermore, the call processing module 1040 of the TTI 1030 has a CFF 1025 that participates in call forwarding of calls to and from the external network devices by providing local call forwarding functionality as

15   a forwardee or an originator, respectively, for the external network devices outside the network. For example, in Figure 8C a signaling sequence similar to that of Figure 8A is shown except that the third network device 1003 of Figure 8A is replaced with the TTI 1030. In particular, in this case

20   the TTI 1030 provides call forwarding functionality as a forwardee on behalf of an external device (not shown) external to the network 1000. In particular, in Figure 8C the refer request contains a call forwarding destination for the external network device and the call setup message is

25   sent to the TTI 1030. In Figure 8C, the TTI 1030 then sends a call setup message 860 to the external network device to initiate a call. Alternatively, depending on a gateway mechanism used by the TTI 1030, the TTI 1030 relays the call setup message 820 to the external network device. The call

30   setup message being relayed might be in the form of any suitable signaling or messaging. Note that in some embodiments of the invention the TTI 1030 is adapted to provide local call forwarding functionality on behalf of the

external network device in accordance with the messaging of
Figure 8B.

In another example, the TTI 1030 participates in a
call forwarding of a call from an external network device
5   outside the network 1000 directed to the second network
device 1002. In particular, the call is forwarded to the
third network device 1003. In such a case, in Figure 8D the
TTI 1030 follows the same messaging sequence followed by the
first network device 1001 as shown in Figure 8A except that
10   a call setup message 870 is received by the TTI 1030 from an
external network device (not shown). The TTI 1030 receives
the call setup message 870 and initiates a call with the
second network device 1002 by way of call setup message 800.
Alternatively, depending on a gateway mechanism used by the
15   TTI 1030, the TTI 1030 relays the call setup message 870 to
the second network device 1002. Upon receipt of the refer
request 810, the TTI 1030 sends call setup message 820 to
the third network device 1003. Note that in some
embodiments of the invention the TTI 1030 is adapted to
20   provide local call forwarding functionality on behalf of the
external network device in accordance with the messaging of
Figure 8B.

In Figures 7A and 7B there are four network
devices 1001, 1002, 1003, 1004; however, in other
25   embodiments of the invention any appropriate number of
network devices can be employed. Furthermore, in Figure 7B
there is only one TTI 1030; however, in other embodiments of
the invention any appropriate number of TTIs can be
employed.

30   Further embodiments will be now described with
reference to Figures 9 and 11 to 13. In Figure, 9 and 11 to
13 messaging between network devices will be described for

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example implementations in the context of SIP (Session
Initiation Protocol); however, the invention is not limited
to implementations using SIP. For example, in some
implementations the H. 323 (packet based communication
5   system standard communication system) standard is used.
Furthermore, in Figures 9, 10, and 11 to 13, call forwarding
is applied to network devices 1001, 1002, 1003, 1004 of
Figures 7A and 7B; however, the call forwarding
functionality is also equally applicable to any network
10   device such as terminal sets 101, 102, 103, 104, 105 of
Figure 1 for example.

An example implementation of messaging for call
forwarding in a distributed peer-to-peer network is shown in
Figure 9. In the example, the first network device 1001
15   calls the second network device 1002 by sending an INVITE
message 900 for an incoming call. The second network device
1002 processes the INVITE message 900 and determines whether
or not the call requires to be forwarded. In the example of
Figure 9, each network device 1001, 1002, 1003, 1004 is
20   assumed to have an audio interface (not shown) adapted to
generate a ringing signal upon receipt of the incoming call.
In the example, a ring count expires triggering call
forwarding. A call forwarding destination for the third
network device 1003 is looked-up and packed in a REFER
25   request 910 which is sent back to the first network device
1001. Upon receipt of the REFER request 910 the first
network device 1001 sends a new INVITE message 920 to the
third network device 1003 which corresponds to the call
forwarded destination provided by the second network device
30   1002 in the REFER request 910. The third network device
1003 answers the INVITE message 920 from the first network
device 1001 by sending an OK message 930. The first network
device 1001 then sends an ACK (ACKnowledge) message 940 to

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the third network device 1003 and a media path 950 between
the first and third network devices 1001, 1003 is
established. The third network device 1003 processes the
call from the first network device 1001 and optionally
5   displays the intended recipient of the call. Alternatively,
upon receiving the INVITE message 920, the third network
device 1003 forwards the call using the same procedure as
that used by the second network device 1002.

Referring to Figure 10, and with further reference
10 to Figure 9, shown is a flow chart of a method of
determining whether or not a call requires to be forwarded.
In particular, the flow chart of Figure 10 is used to
describe a method of determining whether or not a call
associated with the INVITE message 900 of Figure 9 from the
15 first network device 1001 to the second network device 1002
requires to be forwarded. The second network device 1002
receives the INVITE message 900 (step 1041) and at step 1042
if the call associated with the INVITE message 900 is not
intended for the second network device 1002 then call is
20 handled for backup processing (step 1044). At step 1044, the
call may be forwarded to another network device or processed
for voice mail for example. In one example implementation
if the network device receiving the call is designated as a
backup for the network device for which the call intended
25 then if voicemail or call forwarding is enabled then the
call is then processed for voice mail or forwarded,
respectively; otherwise, a busy message is sent. At step
1042, if the call associated with the INVITE message 900 is
intended for the second network device 1002 then the second
30 network device 1002 determines whether it is busy and
"forward on busy" is enabled or whether it has unconditional
call forwarding enabled (step 1043).

At step 1043, f the second network device 1002 is busy and "forward on busy" is enabled or if unconditional call forwarding is enabled then step 1043 is performed.

At step 1043, if unconditional call forwarding has
5   not been enabled then the second network device 1002 checks to see if a call forwarding after N rings option has been enabled (step 1046) where N is an integer satisfying $N \geq 1$ with N preferably satisfying $N = 4$. If the call forwarding after N rings option has not been enabled the second network
10 device 1002 enables its ringer and waits for a user at network device 1002 to answer the call (steps 1047, 1048). At step 1048, if the call is answered it is processed (step 1049).

At step 1046, if the call forwarding after N rings
15 option has been enabled then the second network device 1002 starts its ringer (step 1050). At step 1051, if the call is answered it is processed (step 1049); otherwise, the second network device 1002 determines whether the number of rings reached N rings or whether a timer has expired (step 1052).
20 If the number of ring has not reached N rings, ringing continues (step 1050). In the case when either the timer has expired or the specified number of rings has reached N rings then at steps 1053 if forward to voice mail is enabled the call is handed to a voice mail module for further
25 processing (step 1054); otherwise, the call forwarding destination is packed in the REFER request 910 and the REFER request 910 is sent to the first network device 1001 (step 1045). In particular, at step 1045 the call is referred to another network device corresponding to the third network
30 device 1003 in this example, by looking up a call forwarding destination and sending the call forwarding destination as part of the REFER request 910 which is sent to the first network device 1001.

Referring to Figure 11, shown is a signal flow diagram of an example implementation of call forwarding in a distributed peer-to-peer network when a target network device is cannot be reached. In the example of Figure 11, the target network device which corresponds to the second network device 1002, cannot be reached. This might be due to network failure, network device failure, or the network device being unplugged or having a lack of resources, for example. The first network device 1001 attempts to contact the second network device 1002 with successive INVITE messages 1110 but the second network device 1002 does not respond. The first network device 1001 maintains destination addresses for backup network devices and after several attempts looks up a destination address of a first backup for the second network device 1002. For the purposes of this example, the first backup corresponds to the third network device 1003. The first network device 1001 sends an INVITE message 1120 to the third network device 1003. In some implementations, the first network device 1001 looks-up the status of the third network device 1003 to determine whether INVITE message 1120 is to be sent or not. The INVITE message 1120 is processed in a similar manner as described above with reference to Figure 8A; however, in this case the call was originally intended for the second network device 1002. As such the third network device 1003 looks-up a call forwarding destination on behalf of the second network device 1002. Preferably, the call forwarding destination is looked up locally in a table which is maintained by the third network device 1003. Alternatively, the call forwarding destination might be looked up at a central location. In this particular example, the call forwarding destination corresponds to the fourth network device 1004. The third network device 1003 packs the call forwarding destination for the fourth network device 1004 in

a REFER request 1130 and sends the REFER request 1130 to the first network device 1001. In some cases call forwarding to voice mail is enabled in which case the call is processed using voice mail. The REFER request 1130 is sent back to
5 the first network device 1001 and after unpacking the REFER request 1130, the first network device 1001 sends a new INVITE message 1140 to the fourth network device 1004. The fourth network device 1004 answers the INVITE message 1140 from the first network device 1001 by sending an OK message
10 1150. The first network device 1001 replies to the fourth network device 1004 with an ACK message 1160 and a media path 1170 is established. Once the media path 1170 is established, the fourth network device 1004 processes the call and optionally displays the intended recipient of the
15 call, which happens to be the second network device 1002 in this example. Alternatively, upon receiving the INVITE message 1140, the fourth network device 1004 may forward the call using the same procedure as that used by the third network device 1003.

20   In the example implementation of Figure 11, the first network device 1001 maintains destination addresses of backup network devices. In one implementation these backup network devices are preferably defined as discussed above with reference to Figures 1 to 6 in which backup
25 functionality is provided not only for purposes of call forwarding but also for other call processing features such a voice mail for example; however, it is to be understood that for purposes of call forwarding in other implementations the backup network devices are defined
30 separately from backup network devices defined for other call processing features.

       Referring to Figure 12, shown is a signal flow diagram of an example implementation of call forwarding in a

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distributed peer-to-peer network, according to another
embodiment of the invention. In the example implementation
of Figure 12, the first network device 1001 calls the second
network device 1002 by sending INVITE message 1210. The
5 second network device 1002 processes the INVITE message 1210
and determines whether or not a call associated with the
INVITE message 1210 requires to be forwarded, as described
herein above with reference to Figure 10 for example. In
the case when the call requires to be forwarded, a call
10 forwarding destination is looked up and an INVITE message
1220 is sent by the second network device 1002 to a call
forwarding destination associated with the third network
device 1003. The third network device 1003 processes the
call initiated by the INVITE message 1220 and optionally
15 displays the intended recipient of the call, which happens
to be the second network device 1002. The third network
device 1003 responds to the INVITE message 1220 with a
RINGING message 1225 sent to the second network device 1002
and when a user at the third network device 1003 answers the
20 call, an OK message 1230 is sent back to the second network
device 1002 to indicate that the call has been answered.
Upon receiving the OK message 1230 from the third network
device 1003, the second network device 1002 sends an OK
message 1240 containing a reference to the third network
25 device 1003. The reference might be for example an IP
address, an IP address and port number, or a DN (Directory
Number) of the third network device 1003 for example. In
some embodiments of the invention, the OK message 1230 also
contains contact information, an identification of ports of
30 the third network device, and media information. The first
network device 1001 then completes the call set up by
sending an ACK message 1250 directly to the third network
device 1003 instead of completing the call set up through

the second network device 1002. A media path 1260 is then established.

In Figure 12, the OK message 1240 contains a reference to the third network device 1003 and in Figure 9
5 the refer request 910 contains a call forwarding destination of the third network device 1003. More generally, a message sent from the second network device 1002 to the first network device 1001 contains destination information of the third network device, the destination information being a
10 reference to the third network device 1003 or a call forwarding destination of the third network device 1003.

In some embodiments of the invention, the INVITE message 1220 contains a reference to the first network device 1001 and the OK message 1230 is sent directly to the
15 first network device 1001 instead of the second network device 1002.

Referring to Figure 13, shown is a signal flow diagram of an example implementation of call forwarding in a distributed peer-to-peer network when a target network
20 device cannot be reached. In this example, the target network device corresponds to the second network device 1002, which cannot be reached. This might be due to partial network failure, network device failure, or the network device being unplugged or having a lack of resources for
25 example. The first network device 1001 attempts to contact the second network device 1002 by sending INVITE messages 1310 but the second network device 1002 does not respond. After several attempts at establishing a connection by sending INVITE messages 1310, the first network device 1001
30 looks up its routing table (not shown), retrieves a destination address of a first backup for the second network device 1002 which, for the purposes of this example, is shown to be the third network device 1003. The first

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network device 1001 then sends a INVITE message 1320 to the
third network device 1003. The INVITE message 1320 is
processed in a similar manner as described herein above with
reference to Figure 10 to determine whether a call

5   associated with the INVITE message 1320 sent to the third
network device 1003 requires to be forwarded. If the call
requires to be forwarded, a call forwarding destination for
the fourth network device 1004 is looked by the third
network device 1003 on behalf of the second network device

10 1002 and an INVITE message 1330 is sent by the third network
device 1003 to the fourth network device 1004. The fourth
network device 1004 processes the call and optionally
displays an intended recipient of the call, which
corresponds to the second network device 1002. The fourth

15 network device 1004 responds to the INVITE message 1330 sent
by the third network device 1003 with a RINGING message 1335
and when a user at the fourth network device 1004 answers
the call, the fourth network device 1004 sends an OK message
1340 back to the third network device 1003 to indicate that

20 the call has been picked up. Upon receiving the OK message
1340 from the fourth network device 1004, the third network
device 1003 sends an OK message 1350 containing a call
forwarding destination for the fourth network device 1004 to
the first network device 1001. The call forwarding

25 destination might be for example an IP address or a DN.
Furthermore, in some embodiments, the OK message 1350 also
contains contact information and an identification of ports
of the fourth network device 1004. Upon receipt of the OK
message 1350, the first network device 1001 then completes a

30 call set up with an ACK message 1360 which is sent to the
fourth network device 1004. Once the ACK message 1360 is
received by the fourth network device 1004, a media path
1370 is established.

The forgoing merely illustrates the principles of
the invention and it will thus be appreciated that those
skilled in the art will be able to devise numerous
alternative arrangements, which, although not explicitly
5 described herein, embody the principles of the invention and
are within its spirit and scope. For example, the inventive
concept was described for a distributed or particularly
distributed systems; however, in some embodiments of the
invention network devices have local call forwarding
10 functionality and are implemented in non-distributed or
partially distributed systems.

Numerous modifications and variations of the
present invention are possible in light of the above
teachings. It is therefore to be understood that within the
15 scope of the appended claims, the invention may be practised
otherwise than as specifically described herein.